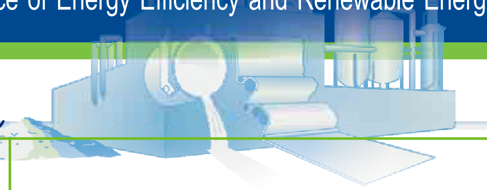
Industrial Technologies Program

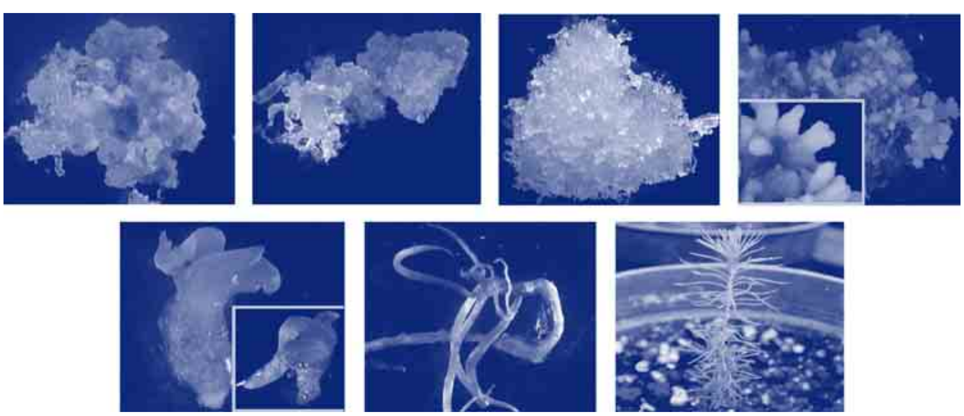


Improved Wood Properties through Genetic Manipulation: Engineering of Syringyl Lignin in Softwood Species

Genetic manipulation of softwood with hardwood genes promises to reduce pulp operation costs, increase yield, and decrease toxic emissions

Greater than 80 million tons of pulp is produced per year by the U.S. pulp and paper industry, the second most energy-intensive industry group in the U.S. manufacturing sector. Of this, the majority is produced from softwoods through the kraft chemical process. In this process, wood chips are treated by chemicals and heat to remove lignin, the polymer which holds cellulose fibers in plants together to make rigid cell walls. It has been determined that lignin is the wood property that most directly affects the levels of energy, chemical, and bleaching required in kraft pulp production. Softwoods contain a type of lignin that is more resistant to chemicals than that found in hardwoods.

Replacing the more chemically resistant guaiacyl (G) lignin with the less resistant hardwood guaiacyl (G)-syringyl (S) lignin would reduce the energy, chemical, and bleaching required in kraft pulp production of softwoods. In addition to reduced manufacturing costs, the genetically engineered softwood would also lead to increased pulp production and lower toxic emissions at pulp mills.



The stages of In vitro *regeneration of black spruce via somatic embryogenesis.*

Benefits

- *35% energy use reduction in softwood pulp mills*
- *Reduced chemical usage*
- *10% increase in pulp yields per unit of wood*
- *50% TEF (toxicity emission factor) reduction*
- *Quality improvements of pulp and paper from softwood species*
- *New technology to maintain U.S. competitiveness in global market*

Applications

Softwood trees grown with the genetically engineered hardwood syringyl lignin would replace the current softwood used by U.S. kraft chemical process pulping mills.

Project Description

Goal: Genetically engineer higher value softwood pulpwood species with a broad range of syringyl lignin quantities that would benefit the industrial users with substantial production cost savings.

An *Agrobacterium*-mediated gene transfer system will be used to simultaneously transfer the aspen hardwood syringyl lignin genes (coniferaldehyde 5-hydroxylase [CAld5H], O-methyltransferase [AldOMT], and sinapyl alcohol dehydrogenase [SAD]) into the model softwood, black spruce, to engineer syringyl lignin in xylem-specific and constitutive manners. After tree propagation, molecular, genetic and biochemical characterization of the transgenic tissues and trees will be preformed to isolate the trees with the highest CAld5H, AldOMT, and SAD protein levels. The isolated transgenic trees will undergo high throughput lignin, cellulose, and fiber morphology characterization.

Progress and milestones

- Three genes (CAld5H, AldOMT, and SAD) responsible for S lignin production in various hardwoods, including Aspen, have been identified and cloned.
- An efficient *Agrobacterium*-mediated simultaneous multiple-gene transfer system and whole-tree regeneration system through somatic embryogenesis for black spruce has been established.
- Project collaborators have expertise in quantifying lignin, cellulose and fiber length, width, and coarseness of tree species using high throughput microanalytical techniques, and will be able to extend this expertise to quantify the lignin S/G ratio.

Project Partners

North Carolina State University
National Renewable Energy Laboratory
Michigan Technological Univ.
ArborGen, LLC
MeadWestvaco Corporation
Weyerhaeuser Company
International Paper Company

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A Strong Energy Portfolio for a Strong America
Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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